INVESTIGATIONS OF THE CHANGE OF WIND WITH ALTITUDE IN CYCLONES.

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In this work the author discusses cyclones with reference to the relations between wind direction and velocity at various levels to the pressure distribution prevailing at those same levels. The cyclones are divided into quadrants designated "front," "right," "rear" and "left," consideration being given, in deciding upon the quadrant in which an observation should be placed, to the direction of progression of the cyclone itself; and the quadrants are further divided into an inner and an outer region. Thus are taken into account the well-known facts (1) that pressure systems change with height; (2) that cyclones are moving formations and that their inertia manifests itself in a different behavior of the wind on their front and rear sides; and (3) that the pressure gradient usually increases for some distance from the centers of cyclones outward and then decreases. The study was confined for the most part to conditions over Germany.

In the absence of sufficiently well distributed kite flights it was necessary to construct isobaric charts at various heights by an extrapolation of the sea-level pressures. This was accomplished by computing free-air pressures from the observed sea-level pressures and surface temperatures; in doing this a constant temperature gradient of 0.5° C per 100 meters was assumed. In some cases it was possible to compare computed pressures with those actually observed in kite flights; as a result of such comparison it was found that there was good agreement up to 1000 m.; moderately good up to 1500 and 2000 m.; above these levels the extrapolated values could not be used. The charts finally used—103 at the surface and at 500 m., decreasing in number to 79 at 2000 m.—showed a flattened form of the isobars and a shifting of the center backward and to the left in the upper levels. These tendencies are most decided of course when the horizontal temperature gradient is steepest.

Wind directions and velocities, as observed on the selected days by means of kites and pilot balloons, were then studied in connection with the isobaric charts. The deviation angle, i. e., the angle between the wind and a line perpendicular to the tangent of the isobar, and the ratio of the observed to the gradient velocity were measured. The results, when all cases are considered and when a few typical cases are selected, are set forth separately, but the differences are not large. In general the deviation angle increases rapidly from the surface to 500 m., then more slowly up to 2000 m., where it is nearly 90°, i. e., the wind is practically at right angles to the pressure gradient. The component toward the center of the cyclone is greater in front than in the rear, due of course, to the forward movement of the cyclone. There appears to be no consistent difference in the deviation angle in the inner and outer regions of cyclones. The ratio of observed to gradient velocity increases rapidly from the surface to 500 m., but above that level remains relatively constant—in most cases somewhat less than 1; in other words, the gradient velocity is not quite reached, on the average. There is little difference in this ratio in the different quadrants, but it appears to be somewhat larger in the outer than in the inner region of cyclones.

It is pointed out that the difference in the deviation angles in the front and rear of cyclones has a very direct connection with the movement of those cyclones. The convergence in front tends to increase cyclonic circulation; the divergence in the rear tends to decrease it. Since the movement will be toward the region of strongest convergence, observations of the latter in individual cases should help materially in determining probable storm movement.

DISCUSSION.

Meteorologists have long recognized the necessity of having accurate representations of free-air pressure distribution before much further progress can be made in forecasting. Particularly urgent is the need for these, now that specialization in forecasting for aviators is receiving so much attention. The author of the work above reviewed has made a careful and well-planned study of the subject, and in general the method of treatment is entirely logical. The results are compared with those of other investigators, and the different conclusions reached are shown to be due to the fact that earlier students considered the free-air winds in relation to sea level pressure distribution instead of that at the level of the winds themselves. There is no question as to the nonconformity of free-air isobars to those at sea level, except occasionally when horizontal temperature gradients are very weak. (This condition seldom occurs in cyclones.) In a study of the dynamics of the free atmosphere the method employed by some investigators of considering free-air winds in connection with sea-level pressures is therefore quite erroneous. Misleading impressions are made on the mind of the reader, unless care is taken continually to keep before him the actual basis of comparison; on this basis no real progress is possible. From a practical point of view, however, this method of treatment has its advantages. It is frequently the case that free-air observations can not be made in certain regions and that lack of time does not permit the meteorologist to construct free-air isobaric charts. In such instances a tolerably accurate forecast can be made, based on the results of the studies just referred to. Of particular value are these relations to aviators, who naturally wish to know what the conditions are, not the reasons for them.

The author points out a possible weakness in her method of computing free-air pressures, viz., that of assuming everywhere a temperature gradient of 0.5° C. per 100 meters., but defends this method by citing the average values in cyclones as determined by Peppler.[1] This is true when the mean gradient up to 2000 m. for the year is considered. There are very appreciable variations, however, for the different levels and there are large *seasonal* differences. It is believed that the latter at least should have been considered. An idea of the importance of these may be gained from an examination of figures 5 to 10 in a paper recently published by Mr. Meisinger.[2] These figures and the accompanying text bring out clearly the variations in the free-air temperature gradient with height, season and wind direction and indicate that these variations can not be ignored. What are needed more than all else, as the author remarks, are numerous *current* observations, so that the free-air pressure distribution may be *known*, not estimated. We all join in the hope that this condition may soon be realized.—*W. R. Gregg*.

[1] Die vertikalen Gradienten der Temperatur und die Schichtungen in den Cyklonen und Anticyklonen. *Beitr. z. Phys. d. fr. Atm.*, Bd. IV, S. 67, 1912.
[2] Meisinger, C. LeRoy. Preliminary steps in the making of free-air pressure and wind charts. MO. WEATHER REV. May, 1920, pp. 251-263.